Art. XXI.—*The Structure of an Australian Land Leech.*

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Communicated by Professor Baldwin Spencer.

(With Plates X., XI., XII., XIII., XIV.)

[Read 9th December, 1897].

At the suggestion of Professor Baldwin Spencer, and under his supervision, I have undertaken the following work on the structure of an Australian Land Leech.[1]

To him my best thanks are due for his kindness in allowing me the use of the Biological Laboratory, where my researches have been carried on, for specimens placed at my disposal, and especially for much helpful advice and criticism.

I wish also to acknowledge my gratitude to Mr. C. French, Government Entomologist of Victoria, for his untiring efforts to secure specimens. The temporary disappearance of late of the land leech usually so abundant in the gullies round Melbourne, is, owing probably to a succession of exceptionally dry seasons during the past few years.

Further, I take this opportunity of thanking Dr. J. Chalmers Baird, Mr. M. P. Fox, and Dr. O. V. Lawrence, for Victorian specimens; also Mr. Eff. D. Lawrence, to whom I am indebted for Tasmanian specimens.

Land leeches are found in various parts of Victoria, chiefly in the gullies of the ranges, specimens having been obtained from Fern Tree Gully, Beaconsfield, Healesville, Omeo and Gippsland, in Victoria; the Western Tiers in Tasmania; and the Blue Mountains in New South Wales. They are found crawling over ferns, mosses, and damp logs, with their characteristic loop-like

1 The species here dealt with is *Philæmon pungens*, which was named by Professor Blanchard from specimens sent to him by Professor Spencer. The description of the species has not yet been published.

movement. It has not yet been ascertained that the New South Wales is identical with the Victorian, which is, however, certainly the same species as the one named by Professor Blanchard from Tasmania.

So far as is known at present the land leech is not found in South Australia, a fact to be accounted for, doubtless, by the dryness of the atmosphere, and lack of moisture in the gullies.

This little animal varies much in size. When contracted in spirit some specimens are but 7 or 8 mm. in length, others—the Tasmanian—measure from 25 to 30 mm.

Whitman[1] in his paper on the leeches of Japan says: "The Australian species, for which I am indebted to Mr Haswell, differs from all other species, that I have thus far examined, in having only two jaws. The latero-ventral jaws are present, but the median dorsal jaw is entirely absent. This remarkable distinction, taken together with the fact that the genital orifices are separated by seven and a half rings instead of five as in the case of most other land leeches, seems to make necessary the establishment of a new genus, for which I propose the name Geobdella."

This evidently differs from the leech under investigation, for though the lattter possesses but two jaws, there is no doubt whatever that the genital openings are separated by four rings only, which is an indication that a typical segment consists of four annuli. Until Professor Blanchard's recent work it was generally stated that in the Gnathobdellidæ each unabbreviated somite possessed five annuli. Many species belonging to this family, however, have been shown to form exceptions. Professor A. Oka in his paper on "Some new Japanese Land Leeches" (1895) has described three new species belonging to an entirely new genus, to which he gives the name Orobdella. The number of rings in an unabbreviated somite, characteristic of this genus, varies, but is constant for each species. Thus *O. whitmani* has in all eighty-eight rings, each complete somite consisting of four rings. *O. ijimai* one hundred and twenty-nine with six forming a segment, and *O. octonaria* one hundred and seventy-one, with somites of eight rings each.

[1] Q.J.M.S., No. 26, 1886, p. 317.

Professor Blanchard, as quoted by Oka,[1] divides the Hirudinea into :—

1. Rhynchobdellidæ.
2. Arhynchobdellidæ.

Fam.—Gnathobdellidæ.

Aquatic.—Hirudo, etc.

Terrestrial.—Hæmadipsa, Xerobdella, Mesobdella.

Fam.—Herpobdellidæ.

Aquatic.—Herpobdella, Trocheta.

Terrestrial.—Cyclicobdella, Lumbricobdella, Orobdella.

According to the characteristics of the genera of the Gnathobdellidæ, whose members are exclusively terrestrial, the Australian land leech resembles Hæmadipsa more than any of the others. It possesses five pairs of eyes, a point in common with Mesobdella but differing from Xerobdella. Philæmon, however, is unlike these three genera, in that it has but two denticulated jaws.

In counting the annuli or rings, and fixing the boundaries of the somites of the leech, different workers have adopted different methods. Some begin with the first oculiferous ring on the dorsal surface, others with the first complete ring on the ventral. Oka, in the paper on the Japanese Land Leeches, already referred to, mentions these different methods and adopts Apathy's plan of counting every ring in the body, whether in front of or behind the first pair of eyes, as being the least artificial. He also calls attention to the fact that "each apparent ring at the anterior extremity of the body has not of necessity the value of one morphological ring." In the present paper I have counted every ring, incomplete as well as complete. The first complete annulus is situated immediately behind the fourth pair of eyes (Figs. 1, 2 and A), and this, together with the one following it, forms the lower lip of the anterior sucker (Figs. 1 and A). The complete annuli extend on the ventral surface to the acetabulum (76th annulus), making in all seventy-two complete rings. At the

[1] On Some New Japanese Land Leeches. Journal of the College of Science, Imp. Univ., Japan, vol. viii., 1895, p. 302.

anterior end, in front of the first complete ring, there is at the dorsal surface an annulus bearing the fourth pair of eyes. The first three pairs situated in front of these no doubt represent rings but are not easily distinguishable.

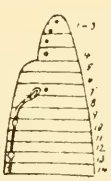

FIGURE A.

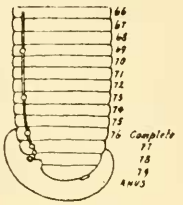

FIGURE B.

At the posterior end behind the last complete annulus there are three incomplete rings which end at and help to form the papilla-like structures beneath which opens the last pair of nephridiopores (Figs. 2 and 4).

Thus there are in all seventy-nine annuli; at the anterior end three, or their representatives, followed by one incomplete ring, then seventy-two complete annuli, and behind these, three seen only on the dorsal surface.

Considering the first three pairs of eyes to be on rings of their own, the fourth pair is borne on the 4th ring, and the fifth pair on the 7th, that is the third complete ring.

Whitman[1] in the paper previously quoted from on the Leeches of Japan calls attention to this arrangement, and says that this absence of a ring between the third and fourth pair of eyes is characteristic of all land leeches. Counting back from the anterior end, there are on the mid-ventral surface two small openings, one, the male reproductive aperture on the posterior edge of the 26th annulus, the other, the female on the posterior border of the 30th.

It has been shown by De Quatrefages, Gratiolet, Vaillant, and Bourne, as quoted by the latter,[2] that the annulations of the leech do not represent true somites. These are made up of three or more annuli according to the genus and species.

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1 *Loc. cit.*, p. 324.

2 Contributions to the Anatomy of the Hirudinea, Q.J.M.S., vol. xxiv., 1884, p. 42.

Whitman determines the segments by the position of the segmental papillæ, which he states are present on the first ring of every somite. Oka is unable to fix the somites by this means and points out that if these papillæ were as distinct in all species as those described by Whitman it would not be difficult to make out the somites and the number of annuli contained in each. I have found the same difficulty in determining the somites by the papillæ. In many of the specimens it is quite impossible to detect any such sensory organs except by means of sections; other leeches, however, which resemble the former in every respect, possess on every fourth ring twelve papillæ. These are definitely arranged as shown in Fig. 3, and occur in constant relation to the external markings of the leech. Along the mid-dorsal surface from the anterior to the posterior end of the body is a narrow light brown band, on each side of which is a broad and darker area extending to the lateral-ventral margin. Immediately on either side of the mid-dorsal band, except at the extremities, is a series of pale grass green patches of pigment. Each patch extends through three annuli, and at its anterior and posterior end is a papilla, that is, every fourth annulus, and only every fourth, possesses segmental papillæ. The green patch is outlined in very dark brown, almost black, colouring matter. On the lateral edge, where the dark dorsal area meets the pale ventral surface, another papilla occurs, and midway between this and the dorsal papilla is a third, so that on the dorsal surface there are six segmental papillæ—that is, three on each side of the middle line.

The under surface of the leech is of a uniform light brown colour, and on the ventral surface of each papilla-bearing annulus there are, as on the dorsal, six papillæ.

As is seen in Fig. 1 there are four annuli between the male and female genital openings. By means of sections I find that the nephridiopores occur on every fourth ring, and there are also four annuli between each of the sixteen nerve ganglia in the region of the body. Therefore, it may be concluded that there are four annuli to each unabbreviated somite.

Pontobdella among the Rhynchobdellæ and *Orobdella whitmani* of the Arhynchobdellæ are the only other leeches as yet described which agree with Philæmon in this respect.

Having ascertained the topographical relation of the external rings to the nervous ganglia, these being taken on account of their more regular metameric arrangement, we may, by comparison with other leeches call the annulus in which the ganglion lies the first annulus of the somite. The nephridiopores—two—open on the posterior edge of the annulus in front of the one bearing the ganglion that is on the fourth or last annulus of each segment.

The number of somites is, of course, dependent on the number of ganglia. By dissection it can easily be seen that as in all Hirudinea, exclusive of the œsophageal and acetabular nerve masses, there are twenty one ventral ganglia, that is twenty-three ventral ganglionic masses in addition to the supraœsophageal mass. Of these the first or subœsophageal mass lies in part of the 8th and 9th annuli. By means of sections it can be seen to consist of five fused ganglia. This is the case in most other leeches. Comparing this with the structure of the unabbreviated segments where we find one ganglion to every four annuli, that is to every segment, we can only suppose that the first nine annuli containing the subœsophageal mass represent at least five somites.

These, if unabbreviated, ought to consist of twenty annuli. Reduction of the rings, or, what Whitman calls "centripetal abbreviation," has taken place, and the anterior somites have merely kept those rings which are of the highest functional value. By this means the first three segments may be regarded as consisting of three almost indistinguishable rings bearing each a pair of eyes. The next segment, IV., consists of the 4th, 5th, and 6th rings, the first of these bearing the fourth pair of eyes.

The eyes are undoubtedly modified and highly specialised segmental papillæ and ought therefore to be on the first annulus of each segment.

Segment V. begins with the 7th annulus bearing the fifth pair of eyes and has, as in segment IV., two other annuli, the 8th and 9th.

In the next ring the 10th is the second ganglion, so that the œsophageal mass may easily be regarded as consisting of the representative ganglia of the segments I.–V. Between the second and third ganglia there are two rings, so that somite

VI., like IV. and V., may be regarded as consisting of three annuli, the 10th, 11th and 12th.

The third ganglion lies in the 13th annulus, that is the first of somite VII. This is the first unabbreviated segment. Behind this are fifteen, each consisting of four annuli, the eighteenth ganglion belonging to segment XXII., being situated in the 73rd annulus. Altogether there are sixteen unabbreviated somites, beginning with the 13th annulus and extending back to the 76th, the last complete annulus. Reduction of the somites again occurs and we find the nineteenth, twentieth, twenty-first, twenty-second, and twenty-third ganglia are lodged in the acetabulum ventrally and in front of the anus, the anterior ones probably corresponding to the 77th, 78th and 79th annuli. The first four of these are single ganglia and therefore represent somites XXIII., XXIV., XXV., and XXVI. The twenty-third or acetabular mass is, however, a fusion of seven ganglia as can be easily seen either from sections or by examining the ganglion with a lens. This means, therefore, that seven somites are here represented, making in all XXXIII., which is the typical number of somites for all leeches.

The supraœsophageal ganglion lies in the 7th annulus and is connected with the subœsophageal mass by nerve fibres passing round the pharynx. This ganglion, developing as it does, quite independently of the ventral nerve chain, does not represent a segment but the prostomial lobe of the embryo.

The relationships of the ventral ganglia, somites and annuli are shown in the following table :—

	Ganglion.	Somite.	Annuli.
1.	Œsophageal	V. (I.–V.)	7, 8, 9, (1–9)
2.		VI.	10–12
3.		VII. (unabbreviated)	13–16
4.		VIII. ,,	17–20
5.		IX. ,,	21–24
6.		X. ,,	25–28
7.		XI. ,,	29–32
8.		XII. ,,	33–36
9.		XIII. ,,	37–40
10.		XIV. ,,	41–44

	Ganglion.	Somite.	Annuli.
11.	- - - - -	- XV. (unabbreviated) -	- 45–48
12.	- - - - -	- XVI. „ -	- 49–52
13.	- - - - -	- XVII. „ -	- 53–56
14.	- - - - -	- XVIII. „ -	- 57–60
15.	- - - - -	- XIX. „ -	- 61–64
16.	- - - - -	- XX. „ -	- 65–68
17.	- - - - -	- XXI. „ -	- 69–72
18.	- - - - -	- XXII. „ -	- 73–76
19.	- - - - -	- XXIII. - - -	- 77 and acetabulum
20.	- - - - -	- XXIV. - - -	78
21.	- - - - -	- XXV. - - - -	79
22.	- - - - -	- XXVI.- - - -	
23.	Acetabular - -	- XXVII.–XXXIII.	

Oka[1] states that "Apathy and Lang divide the body of a leech into the following regions: cephalic, clitellar, median, anal, and acetabular." In Philæmon it is almost impossible to fix such divisions, as there is no strict line of demarcation between these parts, the one passing by insensible gradations into the other.

The head region may be considered to extend back to the posterior margin of the mouth and consists of the first nine annuli, that is somites I.–V. It carries the five pairs of eyes—the position of which has already been described—and the anterior sucker. This occupies nearly the whole of the ventral surface, the upper lip being formed of the part lying immediately in front of the first pair of eyes, and the lower lip of the 5th and 6th annuli, which are less distinctly separated on the ventral than on the dorsal side. In the anterior sucker lies the mouth, and attached to it are the two jaws. These are placed latero-ventrally and in some contracted specimens can be seen protuding from the anterior sucker. They are situated in somite V. Following on the head region are three somites which may be regarded as forming the neck, the first somite, VI., being the last abbreviated segment at the anterior end.

So far I cannot distinguish a clitellar region. Microscopically, as well as externally, there appears to be not the least difference

[1] *Loc. cit.*, p. 288.

between the integument in the neighbourhood of the genital organs and that of the rest of the body.

As already stated, the male and female reproductive organs open on the 26th and 30th annuli respectively, that is the second annulus of somites X. and XI., so that they occupy a similar position in their respective segments—namely mid-ventral on the posterior border of the second annulus. The median region includes the greater part of the body made up of unabbreviated somites though externally there is nothing which can determine the position or number of annuli in a segment, that is, no clearly distinguishable segmental papillæ and no visible nephridiopores. Each segment in this region possesses a ganglion, from which are given off nerves to the different parts of the segment as well as the portion of the ventral chain connecting the ganglia, a pair of nephridia, each with its excretory vesicle and external aperture, a pair of testes and a portion of the alimentary canal with a diverticulum given off on each side.

The hindermost end, including the anal and acetabular regions, again shows centripetal abbreviation (Figs. 1, 2, 3).

Behind the last annulus, 79th in the mid-dorsal line, is situated the anus on a small muscular papilla attached to the acetabulum.

Integument and Sense Organs.

The integument of this form resembles very closely that of other described land leeches. It consists on the outside of a thin transparent cuticle, beneath which lies the epidermis made up of columnar cells and simple unicellular glands, in many of which the nucleus can be clearly distinguished lying at the side, as shown by Bourne. Distributed among these cells are numerous capillaries supplied from the dorsal and ventral sinuses, and joining together to form vessels pouring ærated blood into the lateral vessels. Here also the pigment is disposed. In certain parts the epidermic cells are modified and specialised to form sense organs. Of these there are the segmental sense organs, the eyes, and the marginal lip organs—or "goblet-shaped" organs of Leydig.

In the main the sense organs of Philæmon resemble those of the leeches worked at by Whitman.

The Segmental Sense Organs. (Fig. 5).

The segmental sense organs occur on the body and head on every fourth annulus. As before stated, there are twelve situated at equal distances from each other round the first annulus of each segment. These organs are covered externally by the thin cuticle continuous over the whole body. Each consists of a group of epidermic cells longer than those of the rest of the surface, and leaning towards one another. At the base of these are four or more large clear cells, such as have been described by Whitman—each with a distinct nucleus lying in the protoplasm and also a crescent shaped vacuole (C.C.1). At the point where the protoplasm projects into the vacuole it appears denser and stains more deeply. It is possible that this may be the terminal ending of a nerve, though I have been unable to trace any definite connection with the clear cell. With this may be compared Whitman's description of the clear cells, in which he observes "a small oval area though the outline of this is not very sharp," and this area he suggests may be the nerve ending, although he cannot prove it. In the very centre are the elongated sense cells which form the important part of the organ. At the anterior end of the body some of these cells have become so drawn out as to resemble the axial fibres of the eye. I have not been able to trace any decided communication, however, between these central cells and the nerve supplying the organ, though undoubtedly there must be a connection—which in the case of Hirudo and Hæmadipsa, Whitman states he could distinctly see.

The organs are richly supplied with blood vessels, a branch usually running out at right angles to the surface of the animal and dividing so as to send branches all round the organ.

At the inner side of the clear cells are the circular muscles of the body wall. The nerve supply is derived from the ganglion of the segment to which each organ belongs.

The Eyes. (Figs. 6 and 7).

As already stated there are five pairs of eyes situated on the 1st, 2nd, 3rd, 4th and 7th annuli. With regard to structure there is little that is new to be said. As in the descriptions

by Professor Whitman[1], Dr. B. L. Maier[2] and Miss Merrill[3] of the eyes of the Hirudo, Hæmadipsa, Clepsine, Macrobdella and others, so in Philæmon the eye appears to be but a more specialised and highly developed segmental sense organ. The most characteristic and conspicuous cells are the large clear cells, each with its nucleus and vacuole. These are placed round the axial fibres, as shown in Fig. 6, in a single layer. Surrounding these is a cup of pigment which is shallower and less dense on the outer posterior portion of the eye. Passing in at one side near the base of this cup is a blood-vessel (bv) which can be traced round to the other side of the cup, so that the eye is well supplied with blood. The tactile cells are somewhat elongated with nuclei visible at their inner ends.

By comparison with Miss Merrill's figures the tactile cells of Philæmon are shorter and more like the ordinary epidermic cells. With little difficulty the axial fibres in the centre can be seen. These, however, in a transverse section of the eye are very distinct. The optic nerves supplying the eyes pass off from the supraœsophageal ganglion. In some cases the nerve appears to enter the eye almost at the base, while in others it distinctly passes in at the sides of the cup. Before entering the eye the nerve divides, one branch being distributed to the cells and fibres in the cup and the other to those at the front end of the eye (Fig. 7). In one section, cells could be seen on the optic nerve, evidently corresponding to those called by Whitman "nerve ganglion cells."

The Marginal Lip Organs. (Fig. 8 and 8a).

These are the goblet-shaped organs of Leydig. They occur only in the upper lip where they are in considerable numbers set all along the margin. Each consists of one or more—generally more—groups of cells.

On the surface, as in the case of the other sense organs, they protrude slightly and are covered by a thin cuticle. The

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[1] *Loc. cit.*

[2] Beiträge zur Kenntniss der Hirundineen-Auges. Zool. Jahrbuch. Bd. v., p. 552.

[3] Preliminary Note on the Eye of the Leech. Zool. Anzeig., xvii., 1894.

epidermic cells are much elongated to form tactile cells (T), with their nuclei placed at their inner ends. A nerve, arising in some cases directly from the supraœsophageal ganglion, in others as a branch of the optic nerve, passes up, giving off branches which supply two or more organs lying next to one another, so that the different sense organs are not necessarily supplied with differently functional nerves. The fibres enter the inner end of the groups of tactile cells and are distributed to them. I have noticed, in some sections, one or two large clear cells (c.c.) placed on the nerve fibres, the function of which I am unable to explain. As in the case of the other sense organs these on the margin of the lip are well supplied with blood by means of small vessels passing up between the ordinary epidermic cells and giving off branches which pass round the organ and supply it on all sides (Bv).

In respect to time of origin Whitman says that the segmental sense organs have been developed first, for the others—the non-segmental—are limited to a specialised part of the animal and have undoubtedly arisen in response to the increased needs of this part.

The functions of these various sense organs have been fully discussed by Whitman.[1] Undoubtedly the marginal lip organs subserve the sense of touch and may possibly serve as organs of smell.

The exact way in which the eyes function as organs of sight is yet to be decided. At least they can appreciate light and darkness. Owing to the fact that the segmental sense organs and the eyes both possess large clear cells—these being most numerous in the latter—Whitman concludes that both classes of organs have a common function, namely, the appreciation of light and darkness. It is also probable that the segmental sense organs act as organs of the sense of smell.

Alimentary Canal. (Figs. C., 4 and 9-19).

The alimentary canal of Philæmon resembles that of *Hirudo medicinalis* in many respects. It opens on the ventral surface at the anterior end by the anterior sucker and extends back along

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1 Q.J.M.S., vol. xxvi., p. 408.

the dorsal surface to the posterior extremity where it opens at the anus (Fig. 4).

The anterior sucker, as already described, occupies the whole of the ventral surface of segments I.–IV. Its upper lip is formed from the prostomium and is set with marginal lip organs (Fig. 8). The ventral lip consists of the 5th and 6th annuli. The sucker is muscular, and by its means the leech attaches itself to its prey for purposes of feeding. The comparatively large cavity behind this may be regarded as the buccal chamber (B.C.) or mouth—the opening from it into the pharynx being the oral aperture. The pharynx wall is muscular and made up of three folds, one median dorsal (D.F.) and two latero-ventral (L.F.). Growing up as continuations of the latero-ventral folds are two muscular jaws which project into the buccal chamber—a jaw corresponding to the median dorsal fold not occuring. The position of the jaws is seen in Fig. 9.

They have the appearance of somewhat rounded disc-like structures, the free edge consists of a thickened cuticle (cut. Fig. 10) forming a definite ridge. Along this ridge can be seen a distinct groove, in which are placed some seventy or more small denticles (D.). The denticles are not placed contiguously, and the groove between any two teeth appears to be to a certain extent closed in or filled up with tissue. This gives the appearance of the tooth being set in a little socket (Fig. 11). The denticles are conical, and curved slightly towards the mid-ventral line, the rest of the surface of the jaws is smooth and covered with the cuticle. It can easily be seen from sections (Fig. 11) that the jaws are exceedingly muscular organs with numerous glandular structures between the denticles (Fig. 12 gl.). There is little doubt that these glands resemble those of *Hirudo medicinalis* described by Croockewit.[1] The glands are unicellular, with long, narrow, waving ducts, which open on the free edge of the jaw between the denticles. The nuclei of these gland cells can be seen in many of the preparations.

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1 Zool. Anzeig., vol. xvi., 1893.

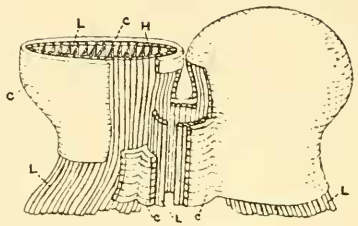

FIGURE C.

Of the muscles of the jaws there are three sets (Fig. C.)

A. Transverse or circular (Figs. 11, 13, C.).

These lie beneath the cuticle, and, except for this thin membrane, form the outermost layer of the jaws. These muscles are absent only where the cuticle is thickened to form the ridge along which the teeth and glands occur. They are really a continuation of the circular muscles of the pharynx on to the jaws.

B. Longitudinal (L.)

Beneath the transverse are situated the longitudinal muscles continuous with the longitudinal of the pharynx and forming a single layer on the jaws, but increasing in size and number of layers where they are attached to the pharynx. At this point some fibres pass into the body wall but the majority run on to form the large mass of muscles on each side of the pharynx gradually merging into the body wall.

C. Dorso-Ventral (H.)

These pass through the jaw from the dorsal to the ventral side, forming its main support. They are seen just beneath the free projecting ridge and cease to exist only at the base of the jaw, where it springs from the pharynx wall.

On account of the number and arrangement of the jaws, the bite from this leech is a longitudinal slit.

Besides the outer circular and inner longitudinal muscles of the pharynx, there is a series passing in a radial direction from the inside epithelial lining to the circular muscles on the outside. These are the radial muscles (R.) and they occur only in the pharynx. The function of this part of the alimentary canal is to draw by suction action the blood, necessary for food, from animals to which the leech becomes attached.

The muscular pharynx (ph.) gives place about the middle of somite VI. to the œsophagus. This is a tube with glandular walls, surrounded by circular muscles. The glands are what I take to be the salivary glands, racemose in appearance, consisting of somewhat large clear cells and opening by very short-necked narrow ducts in the cavity of the œsophagus. This extends through somite VII. where it opens into the crop (Fig. 2), which evidently corresponds to the "stomach" in forms described by Oka and Whitman. The crop is a comparatively thin walled tube giving off eleven pairs of diverticula, one pair in each of the somites VIII.-XVII., while the eleventh pair opens in somite XVIII. and runs back parallel to the intestine as far as somite XXI. The wall of the alimentary canal in this region consists of circular muscle fibres, and a columnar epithelial lining. The alimentary canal throughout its whole length is well supplied with blood vessels. Opening from the crop is a short tube leading directly into the intestine and occupying somites XIX., XX., and XXI. (Fig. 2). This is the stomach. Its walls differ from those of both crop and intestine, in that they are made up of columnar epithelial cells very closely set and almost double the height of those of the crop. On the outside are muscular fibres—circular and longitudinal, among which lie the capillaries and numerous blood vessels. In this part of the canal digestion goes on chiefly, and from the good supply of blood vessels it would appear that absorption also takes place.

The intestine passes from the stomach in the 73rd annulus to the extreme posterior end where it opens to the exterior by the anus (Fig. 4, An.), situated on the dorsal surface in the little groove where the acetabulum joins the body wall. The wall of the intestine resembles in appearance that of the crop—that is short columnar epithelium thrown somewhat into folds so as to increase the surface. It is richly supplied with blood vessels and surrounded by muscular fibres.

Connected with the alimentary canal is a paired structure which, as far as I know, has not been found in any leech hitherto described (Fig. 17, P.O.) This double "posterior organ" lies on the ventral surface just beneath the stomach in somite XIX. The two halves can be distinguished as right and left posterior organs. They lie very close together in the mid-ventral line above the nerve cord, and extend from the fifteenth to the sixteenth ganglia, measuring 2·024 mm. in length.

Their external appearance is that of elongated narrow bodies with longitudinal markings of black pigment (Fig. 17, p.g.). Examined microscopically they are found to be exceedingly glandular organs. The internal surface is thrown into numerous folds (Fig. 18, Fld.) by the growing in of the blood vessels, thus greatly increasing the glandular surface and giving rise to the external longitudinal markings. It is difficult to obtain sections in which the histological structure of this organ can be well determined. The folds are lined by a single layer of modified columnar cells which are vacuolated at the end facing into the cavity of the organ, their outer ends staining deeply. Only very rarely can nuclei be detected.

The blood supply is very rich, vessels passing along the longitudinal grooves and ramifying everywhere through the structure. Slightly towards the inner side of the middle line at the posterior end of each organ a duct opens (Fig. 17, D.P.O.), and is continued back on each side of the stomach and intestine to the eleventh diverticulum of its own side.

Here it passes into the diverticulum (Fig. 19, D.P.O., Dvt. 11) almost at the extreme posterior end and on the inner side. The duct is formed of closely set columnar cells surrounded by connective tissue. (Fig. 19, Col. epi.) With regard to the function of these organs I am unable to offer any suggestion except they are without doubt glandular.

Vascular System (Figs. 20, 21 and 22).

The blood is red and consists of plasma and corpuscles.

In Philæmon as in Hirudo there are four main longitudinal trunks, viz., the dorsal and ventral sinuses, and the two lateral blood vessels.

The dorsal sinus lies close to, and above the alimentary canal. It is a definite structure consisting of a thin epithelial lining surrounded by connective tissue, but possessing no muscle fibres in its walls. With regard to its branches the dorsal sinus may be said to be "segmental," that is the paired branches are at any rate in the middle region, regularly repeated in the different segments, each pair corresponding to and returning blood from each pair of diverticula of the alimentary canal. At the extreme anterior end the dorsal sinus still remains a single channel disappearing in its smaller branches only at about the level of the second pair of eyes.

Between each branch from the diverticula is one bringing back blood from a nephridium. This arrangement continues back as far as the eleventh diverticula. At this point there is the usual pair of vessels from the alimentary canal walls and also the pair from the thirteenth nephridia entering the dorsal sinus at the level of the stomach.

A small branch joins the sinus, returning blood from the ventral and lateral walls of the stomach. Vessels from the fourteenth, fifteenth, sixteenth, and seventeenth nephridia pour their contents into the sinus. Posterior to this is a pair of vessels which collects blood from the intestinal wall by numerous branches. These two vessels unite and form the extreme posterior portion of the sinus.

The ventral sinus is situated immediately within the body wall in the mid-ventral line. The structure of this tube is similar to that of the dorsal sinus. Within it lies the nerve cord.

In each segment, as in the case of the dorsal sinus, vessels open into the ventral sinus, bringing blood from the organs and tissues of the animal, and from the skin of the body wall where it is aerated. The lateral vessels are found just beneath the body wall one on each side of the leech. They are larger than the sinuses, and are more definite in structure (Figs. 20, 21, 22, bv.)

The wall consists of large circular muscles (Fig. 22, cm.) which have the characteristic inner granular part, and the outer cortical layer more solid and definite. Within these muscles is a layer of longitudinal fibres (Fig. 22, LM.), muscular in appearance though very small and taking the stain faintly. These vessels owing to their muscular character play an important part in the circulation of the blood.

Each gives off a series of vessels supplying the nephridia (Fig. 20). These at first retain their muscular character, but on ramifying through the organs their muscularity becomes gradually less marked (Fig. 21 Bv. 2) and finally disappears entirely. The capillaries are distributed through the botryoidal tissue and from these branches arise which enter the sinuses.

Nephridia (Figs. D., 20 and 21).

There are seventeen pairs of nephridia, one pair being situated in each of the segments VI.–XXII.

The nephridium may be divided into three parts for the purpose of description :—

1. The internal, connected with the coelom.
2. The central, making up the greater portion of the organ.
3. The part connected with the exterior.

The internal part connected with the coelom may be called, as in other cases, the testicular lobe, but its structure is different from that of Hirudo. It is intracellular but unbranched, and lies latero-ventrally near the outer margin of the testis. The extreme end of the lobe may be called the funnel (Fig. D., fun.) Owing to the coelom being much reduced there is less work thrown on this part of the organ and it is consequently somewhat modified. Like Hirudo it consists of a group of nucleated cells which may be described as a cauliflower head being thrown into folds. It is, however, much smaller in comparison than that in Hirudo. There is no definite opening from the funnel into the coelom. In this respect it resembles both Hirudo and Aulostomum according to the descriptions given by Bourne and by Graf.[1] As far as I can make out the cells are not ciliated, so that this point and the relation of the funnels to the sinuses show distinct differences as compared with Hirudo and Aulostomum. In Hirudo, Bourne says the funnels lie in a special blood sinus—the perinephrostomial sinus—surrounded by blood and, in those segments containing testes, situated on the dorsal wall of the testes.

In Aulostomum, Graf found that the funnels lie in sinuous vesicles dorsal from the testis and at the side of the intestine.

[1] Q.J.M.S., July, 1884 ; Trans. New York Acad. Sc., xiii., 1894.

In Philæmon the funnels do not lie in any distinct sinus, but are connected with the mass of botryoidal tissue attached on the outer lateral edge to the testis sinus. In the nephridia lying in the segments VI.–XI., anterior to the testes, I have been unable to distinguish any funnels; in all probability there are none present as in Hirudo.

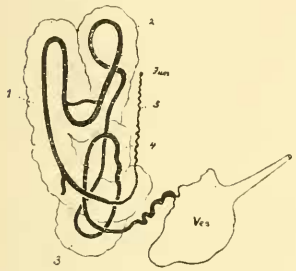

FIGURE D.

The testicular lobe (5) is continuous with the main lobe or central portion, which to some extent resembles the corresponding part in Hirudo. It consists of a primary intracellular duct together with smaller intracellular ducts opening into one another.

The cells are distinctly nucleated and their protoplasm has a radially striated appearance. The general arrangement of the lobes is seen in Fig. D.

The main duct (1) leads from the testicular lobe (3) towards the middle line and then in an anterior direction. Towards the anterior border of the segment it turns sharply on itself. This portion in the diagram is figured Neph. 1, and is continued through about two annuli when it again turns and is regarded together with the next twist as Neph. 2, which is slightly dorsal to Neph. 1. The main duct is continued towards the posterior end of the segment where it coils, forming Neph. 3, passing upwards so as to lie between Nephs. 1 and 2, where it is called Neph. 4. From here the duct is single, that is it has no branches, and is surrounded only by the cells forming it. It passes towards the side and opens into the thin walled vesicle. (Figs. 20 and D.)

The vesicle (ves. Figs. 20 and D.) lies to the outer side of the main portion of the nephridium and towards the posterior end of the segment. It is intercellular, being lined by much flattened cells distinctly uncleated, and outside these are a few muscle fibres and connective tissue.

The main duct of the central portion opens into the vesicle on its inner side, while from its outer lateral margin the excretory

duct passes to the exterior where it opens on the fourth annulus of each segment, and resembles in its marginal position the land leeches of Japan described by Whitman.

With regard to the structure of the excretory duct it may be said that circular muscles occur along the whole of its length. In this respect it resembles Nephelis as described by Graf.[1] The muscles are smaller than those of the body wall, but as far as I can make out they do not increase in number or size at the nephridio-pore, which may account for the difficulty, in fact the impossibility, of detecting the openings on the external surface.

In addition to those which are present along the whole length of the duct, a special and very strongly marked group of fibres forming a distinct sphincter is present where the duct passes out from the vesicle.

So far as their relative size is concerned there is not the strongly marked difference in size between the sphincter muscles and those of the body wall such as Graf describes as obtaining in the case of Hirudo, nor, except so far as size is concerned, does there appear to be any difference in the structure of the two in Philæmon.

I regret that I am unable to refer to the paper by H. Bolsius, mentioned by Graf in his article on the Sphincter of the Terminal Vesicle of *Hirudo medicinalis*. Evidently the sphincter described by Bolsius occurring at the entrance of the duct from the terminal vesicle is similar to that found in Philæmon, in which case the sphincter is formed of a group of circular muscle fibres somewhat smaller than those of the body wall but of the same size as the circular muscles surrounding the rest of the duct.

In a dissection it can be seen that the 1st and 17th pairs of nephridia lying in segments VI. and XXII. respectively differ in appearance from the others. The anterior (1st) is a pinkish white oval mass lying one on each side of the œsophagus towards the dorsal surface, and is much more compact than those of the other segments. The excretory duct from its vesicle runs up in the circular muscles and opens (Fig. 2) on the sixth annulus between the fourth and fifth pairs of eyes—that is on the last annulus of segment IV., there being no external opening in segments V. or

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1 Journ. of Morphology, vol. ix., 1894, p. 485.

VI. The posterior nephridium (17th) lying in segment XXII. resembles in external appearance the majority of nephridia in that it is less compact, but it is larger. The duct, however, from the excretory vesicle passes back and opens on a small papilla-like structure formed by the 78th and 79th annuli, so that is there is no external opening in segment XXII. nor in segment XXIII. (represented by 97th annulus) but the orifice occurs on the posterior edge of what represents segment XXIV. This modification in the arrangement of the 17th nephridium may be compared with that which takes place at the anterior end.

Reproductive Organs. (Figs. E. and 2).

The reproductive organs are situated in the middle region of the body on the ventral side of the alimentary canal and above the nerve cord.

The male organs consist of ten pairs of testes arranged on both sides of the nerve chain in segments XII.–XXI. inclusive. Each testis lies in the second and third annuli of its segment and is spherical in shape. The spermatzoa are developed in these in regular masses as in other cases.

Attached to the lower and outer edge of the testis is a mass of botryoidal tissue. At the outer side of the testis sometimes from its anterior, sometimes from its posterior margin, opens the vas efferens, a small definite walled duct. Each of these vasa efferentia opens into the vas deferens of its own side, which runs from the tenth pair of testes forwards as far as the twenty-sixth annulus, that is about the level of the male external opening.

The vas deferens remains up to this point of uniform size. Here it turns, passing towards the posterior end (on the ventral surface) and becomes exceedingly fine. About the region of segment XII. it dilates into a very thick walled and much coiled tube, which may be called the right or left epididymis. These structures, continuous with their vasa deferentia lie in the middle line dorsal to and about the level of the upper part of the vagina.

The epididymis of the left side lies anterior to the right in the middle line.

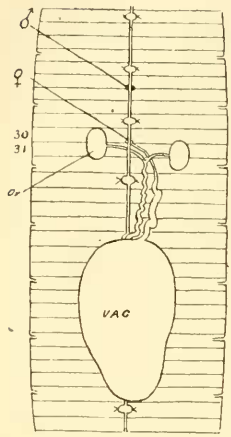

FIGURE E.

About the 39th annulus the epididymis of each side runs forward as a straight tube opening into a somewhat muscular sac which opens to the exterior on the lower edge of the 26th annulus, that is on the second annulus of segment X. The female organs consist of a single pair of ovaries (Fig. E. ov.) lying one on either side of the nerve cord in the 30th and 31st annuli. They are small rounded bodies about the size of the testes and well supplied with blood. From the inner edge of each ovary opens a duct —the right and left oviduct. The left oviduct passes on the ventral side of the nerve chain, and joins the right close to the middle line. The single duct thus formed is somewhat coiled with fairly thick walls. It opens in the 37th annulus into the vagina. This organ (vag.) is large and extends from the 37th to the 48th annulus; it is ovoid in shape, broader at its anterior than at its posterior end. Its walls are exceedngly thick and glandular.

There is no appearance of an albumin gland, such as is found in many other leeches, nor can I detect any particular portion of the vagina wall specially modified to act as such. From the dorsal surface at the anterior end opens the external reproductive duct. This is slightly coiled. It passes to the right of the main duct, underneath, that is on the ventral side of the right oviduct, and opens on the lower edge of the 30th annulus at the female external reproductive opening.

The reproductive organs are well supplied with blood. A branch from the lateral vessel runs along the hair-like continuation of the vas deferens to the epididymus, where it breaks up to supply the walls. The capillaries join together and enter the ventral sinus. Each pair of testes receives its supply from the lateral vessel of its own side, and returns its blood to the ventral sinus.

Branches of the lateral vessel pass to the ovaries and a somewhat large vessel runs along with the external reproductive duct giving off small branches along its course and finally breaking up in the wall of the vagina.

EXPLANATION OF PLATES.

Plates X.—XIV.

Fig. 1. Diagrammatic plan of the annuli and segments of *Philæmon pungens.*

Fig. 2. Diagrammatic plan of the structure of *Philæmon pungens.* The dotted outline represents the alimentary canal. The female reproductive organs are omitted. Two only of the nephridia are represented. The nephridial pores are indicated on the left side, the most anterior pore lying in the sixth annulus. Neph. represents the opening of the last nephridium. The posterior organs are indicated with their ducts opening into the last pair of diverticula of the crop.

Fig. 3. Dorsal view of *Philæmon pungens.* × 3.

Fig. 4. Dorsal view of the posterior extremity of the same. × 6. An. Anus. Neph. 17, opening of posterior nephridium.

Fig. 5. Section through a segmental sense organ drawn under Zeiss, F. oc. 2. The four clear cells are shown. In the upper left hand one the nucleus can be seen. Ax. Axial fibres of the eye. n Nerve.

Fig. 6. Longitudinal section through an eye. Drawn under Zeiss, C. oc. 2. The clear cells are seen lying in the pigment cup. c.c.1. The central projection into the vacuole of the clear cell. Bv. Blood vessel within the pigment cup.

Fig. 7. Outline drawing of a longitudinal section through an eye to show the division of the nerve supplying the organ.

Fig. 8. Section through one of the marginal lip organs. Drawn under Zeiss, F. oc. 2. T. tactile cells. C. cuticle. Bv. blood vessel. Nci. nuclei of tactile cells. Tc. cut ends of tactile cells. C.C. clear cells. N. nerve.

Fig. 8*a*. Small portion of nerve supplying one of marginal lip organs showing ganglion cells on course of nerve fibres. Drawn under Zeiss, C. oc. 2. G.C. ganglion cell.

Fig. 9. View from the ventral surface, much enlarged of the two jaws.

Fig. 10. One of the jaws showing the depressed groove in the cuticle (C) along which the row of denticles is attached (D).

Fig. 11. Transverse section of jaw. Drawn under Zeiss, C. oc. 2. Cut. cuticle. D. denticle. Gl. glandular structure opening between two consecutive denticles. C. circular muscle fibres. L. longitudinal muscle fibres. C.t. connective tissue.

Fig. 12. Transverse section of jaw across a gland lying between two consecutive denticles.

Figs. 13–16. Sections across the jaw in a plane transverse to the length of the body. Drawn under Zeiss, A. oc. 2. The most anterior section is represented in Fig. 13. In Fig. 15 the right half lies anteriorly to the left half. L. longitudinal fibres. C. circular fibres. H. dorso-ventral fibres. Ph. pharynx. D. denticles. Gl. gland. Cc.G. cerebral ganglion. Bv. blood vessel. S.G. subœsophageal ganglion. R. radial muscles. D.F. dorsal fold of Pharynx wall. L.F. the two lateral folds of Pharynx wall.

Fig. 17. Much enlarged view of the Posterior Organs (P.O.). Dvt. II. most posterior diverticulum of crop close to the posterior end of which opens the duct from the Posterior Organs.

Fig. 18. Transverse section of Posterior Organ. Drawn under Zeiss, C. oc. 2. Fld. longitudinal folds on which lie the gland cells.

Fig. 19. Section across the opening of the duct of the Posterior Organ (D.P.O.) into the diverliculum of the

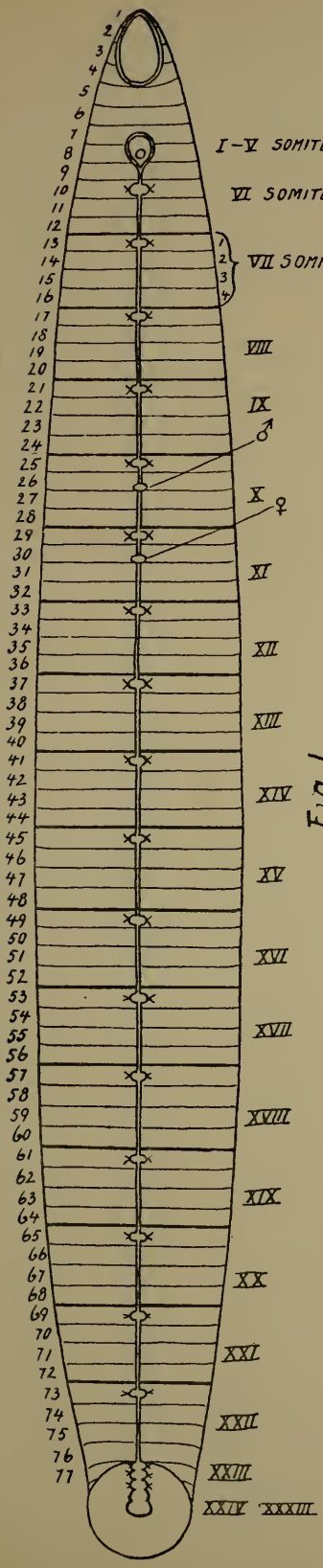
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Fig 1

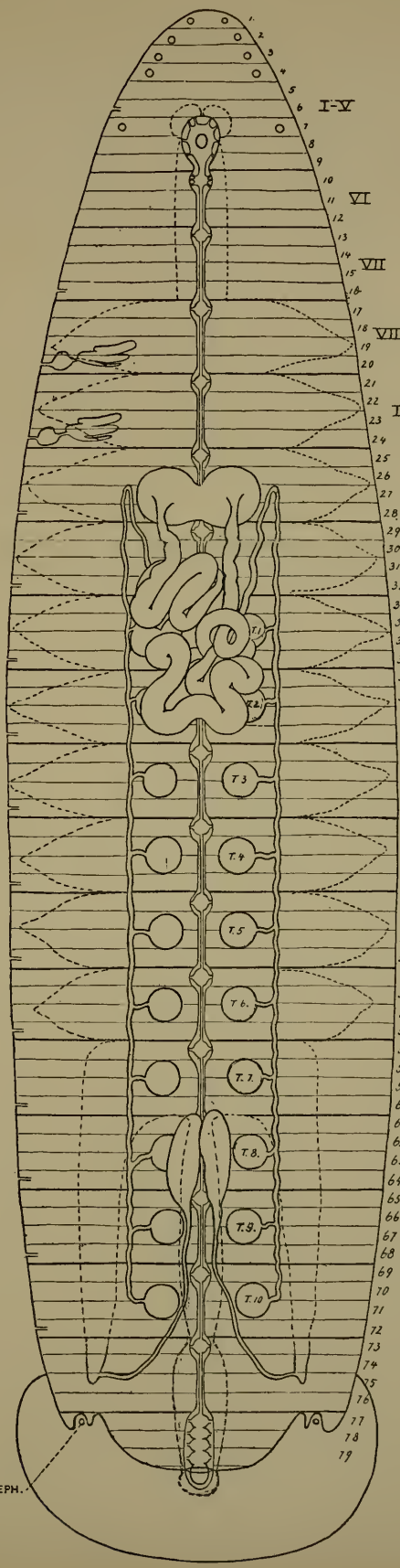
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Fig. 2